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- (54) **SACHET FORMULATION FOR AMINE POLYMERS**
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CPC **A61K 9/0095** (2013.01); **A61K 9/0056** (2013.01); **A61K 31/00** (2013.01); **A61K 31/785** (2013.01); **A61K 8/8105** (2013.01); **A61K 8/817** (2013.01); **A61K 8/898** (2013.01); **A61K 47/34** (2013.01); **A61K 47/36** (2013.01)

- (58) **Field of Classification Search**
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See application file for complete search history.

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(57) **ABSTRACT**

A powder formulation comprises a pharmaceutically acceptable anionic stabilizer and an aliphatic amine polymer or a pharmaceutically acceptable salt thereof mixed with the anionic stabilizer. The powder formulation is conveniently packaged in a container, such as a sachet. A method of treating a subject with hyperphosphotemia with the powder formulation is also disclosed.

28 Claims, No Drawings

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SACHET FORMULATION FOR AMINE POLYMERS

BACKGROUND OF THE INVENTION

Aliphatic amine polymers are effective as phosphate binders and have been described for the treatment of various conditions (see U.S. Pat. Nos. 5,496,545 and 5,667,775). For example, sevelamer hydrochloride, a crosslinked poly(allylamine) polymer, is currently sold under the trademark of RENAGEL® for removing phosphate from patients. Aliphatic amine polymers have also been described for the treatment of hypercholesterolemia (see U.S. Pat. Nos. 5,624,963 and 5,679,717 and PCT Publication Nos. WO98/29107 and WO99/22721). For example, colesevelam, an alkylated, crosslinked poly(allylamine), is currently sold under the trademark of WELCHOL® for reducing serum cholesterol.

However, as the above products are currently available only as tablets, certain patient groups may benefit from the availability of these products in other dosage forms.

SUMMARY OF THE INVENTION

The present invention provides for, inter alia, new compositions and formulations of aliphatic amine polymers. One such formulation is a powder formulation that can be mixed with water and administered orally as a drink (solution or, suspension), while providing acceptable properties to the patient such as mouth feel and taste. Applicants have found that in such formulations, a pharmaceutically acceptable anionic stabilizer, when mixed with the aliphatic amine polymer, can provide acceptable mouth-feel of an aliphatic amine polymer. Based on this discovery, a novel powder formulation for aliphatic amine polymer or a pharmaceutically acceptable salt thereof, a container containing the powder formulation and a method of treating a subject having hyperphosphatemia with the powder formulation are disclosed herein.

In one embodiment, the present invention provides for a container containing a powder that comprises a pharmaceutically acceptable anionic stabilizer and an aliphatic amine polymer or a pharmaceutically acceptable salt thereof mixed with the anionic stabilizer. The powder is uncapsulated and free-flowing.

In another embodiment, the present invention is a powder formulation comprising a pharmaceutically acceptable anionic stabilizer and an aliphatic amine polymer or a pharmaceutically acceptable salt thereof mixed with the pharmaceutically acceptable anionic stabilizer. Preferably, the only pharmaceutically active ingredient in the powder is the aliphatic amine polymer.

The present invention also provides a method of treating a subject with hyperphosphatemia. The method comprises the step of orally administering to the subject the disclosed powder formulation.

DETAILED DESCRIPTION OF THE INVENTION

The disclosed powder formulation comprises an aliphatic amine polymer and a pharmaceutically acceptable anionic stabilizer formulated so as to provide an acceptable mouth-feel. The powder formulation is typically dissolved and/or suspended in an ingestible liquid such as water and therefore can be conveniently administered to a patient as a drink. The drink can be even more palatable with one or more sweeteners and/or flavorants. Such powder formulations may be conve-

niently packaged in a container, such as a sachet or tub. As used herein, the terms "powder" and "powder formulation" are used interchangeably.

The powder formulations of the present invention may further comprise flavorants, sweeteners, excipients, fillers, inert ingredients and the like.

As used herein, "a pharmaceutically acceptable anionic stabilizer" is a compound which comprises an acid functional group (e.g., a carboxylic acid, sulfonic acid, phosphonic acid and the like, or a pharmaceutically acceptable salt thereof), and may substantially improve the mouth-feel of aliphatic amine polymers. The acid functional group is optionally neutralized with one or more pharmaceutically acceptable organic or inorganic bases to form a pharmaceutically acceptable salt. When the pharmaceutically acceptable anionic stabilizer includes more than one acid functional group, the acid functional groups can be partially or completely neutralized. Optionally, some of the acid functional groups can be esterified to form an ester of the acid functional group. Examples of organic or inorganic bases are as described below.

The pharmaceutically acceptable anionic stabilizer typically has a solubility in water of greater than 1 mg/ml and a pKa value less than 9. The pharmaceutically acceptable anionic stabilizer should not interfere with the therapeutic activity of the aliphatic amine polymers, and should not cause unacceptable side effects at the dosages which are being administered.

The molecular weight of the pharmaceutically acceptable anionic stabilizer is not critical in the present invention as long as it has the features described above. Typically, the molecular weight of the pharmaceutically acceptable anionic stabilizer is greater than 1000 daltons. When the molecular weight of the pharmaceutically acceptable anionic stabilizer is greater than 1000 daltons, the charge density of the pharmaceutically acceptable anionic stabilizer is typically equal to or greater than 1 every 1000 daltons.

The pharmaceutically acceptable anionic stabilizer may not be a "pharmaceutically active ingredient".

In one embodiment, the pharmaceutically acceptable anionic stabilizer is an anionic polymer, such as an anionic polypeptide (e.g., a protein), an anionic polysaccharide or a polymer of one or more anionic monomers. Examples of anionic polymers include polymers of mannuronic acid, guluronic acid, acrylic acid, methacrylic acid, glucuronic acid, glutamic acid or a combination thereof, and pharmaceutically acceptable salts thereof. Other examples of anionic polymers include cellulose, such as a carboxyalkyl cellulose or a pharmaceutically acceptable salt thereof. An anionic polymer can be a homopolymer or a copolymer of two of the anionic monomers described above. Alternatively, the anionic copolymer comprises one or more repeat units of the anionic monomers described above and one or more neutral comonomers which are preferably inert and non-toxic. Examples of suitable neutral comonomers which can be used with, for example, olefinic anionic monomers, include vinyl alcohol, acrylamide and vinylformamide. Specific examples of anionic polymers include alginate (e.g., sodium alginate, potassium alginate, calcium alginate, magnesium alginate, ammonium alginate, esters of alginate, etc.), carboxymethyl cellulose, poly lactic acid, poly glutamic acid, pectin, xanthan, carrageenan, furcellaran, gum arabic, karaya gum, gum ghatti, gum carob and gum tragacanth.

In a preferred embodiment, the anionic polymer is an alginate, more preferably an esterified alginate, such as a C2-C5-diol ester of alginate or a C3-C5-triol ester of alginate. As used herein, an "esterified alginate" means an alginic acid in which some of the carboxyl groups of the alginic acid are

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esterified. The remainder of the carboxylic acid groups are optionally neutralized (partially or completely) as pharmaceutically acceptable salts. For example, propylene glycol alginate is an ester of alginic acid in which some of the carboxyl groups are esterified with propylene glycol, and the remainder of the carboxylic acid groups are optionally neutralized (partially or completely) as pharmaceutically acceptable salts. More preferably, the anionic polymer is ethylene glycol alginate, propylene glycol alginate or glycerol alginate. Propylene glycol alginate is even more preferred.

As noted above, the anionic polymer can be used in the form of a pharmaceutically acceptable salt (completely or partially neutralized). As used herein, a "pharmaceutically acceptable salt" refers to a salt prepared from pharmaceutically acceptable acids or bases. For example, the anionic polymers that possess a sufficiently acidic functional group can react with any of a number of pharmaceutically acceptable organic or inorganic bases to form a salt. Examples of salts include alkali metal and alkali earth metals, such as sodium, calcium, magnesium and potassium; zinc; and ammonium salts. Mixed salts are also included. "Ammonium" can be represented as NR'_4^+ where R' is —H or substituted or unsubstituted, linear or cyclic, or saturated or unsaturated alkyl, aryl or araryl. Examples of the ammonium include NH_4^+ and $\text{N}(\text{R}')\text{H}_3^+$, $\text{N}(\text{R}')_2\text{H}_2^+$, $\text{N}(\text{R}')_3\text{H}^+$ and $\text{N}(\text{R}')_4^+$, where R' is C1-C10 alkyl or phenyl.

In another embodiment, the pharmaceutically acceptable anionic stabilizer is an anionic polypeptide, including a protein. Examples of anionic polypeptides include gelatin, casein digest, whey protein, soy protein and polyglutamic acid.

One or more pharmaceutically acceptable anionic stabilizers can be used in the present invention.

The powder formulations of the invention typically include the pharmaceutically acceptable anionic stabilizer and aliphatic amine polymer in a ratio of 0.005-99.9:1 by weight, such as 0.005-50:1, 0.005-10:1; 0.005-3:1, 0.005-1:1, 0.005-0.05:1, and 0.008-0.05:1.

Aliphatic amine polymers are characterized by a repeat unit that includes at least one amine group. Amine groups can be part of the polymer backbone (e.g., a polyalkyleneimine such as polyethyleneimine) or pendant from the polymer backbone (e.g., polyallylamine). Alternatively, both types of amine groups can exist within the same repeat unit and/or polymer. The word "amine," as used herein, includes primary, secondary and tertiary amines, as well as ammonium groups such as trialkylammonium.

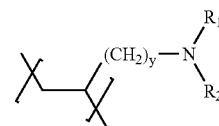
An aliphatic amine polymer may be obtained by polymerizing an aliphatic amine monomer. An aliphatic amine is saturated or unsaturated, straight-chained, branched or cyclic non-aromatic hydrocarbon having an amino substituent and optionally one or more additional substituents. An aliphatic amine monomer is an aliphatic amine comprising a polymerizable group such as an olefin. Suitable aliphatic amine polymers are described in U.S. Pat. Nos. 5,487,888, 5,496,545, 5,607,669, 5,618,530, 5,624,963, 5,667,775, 5,679,717, 5,703,188, 5,702,696, 5,693,675, 5,900,475, 5,925,379, 6,083,497, 6,177,478, 6,083,495, 6,203,785, 6,423,754, 6,509,013, 6,605,270, 6,726,905, 6,733,780 and 6,858,203 and U.S. Published Applications Nos. 2002/0159968 A1 and 2003/0086898 A1, the contents of which are incorporated herein by reference in their entireties.

An aliphatic amine polymer may be a homopolymer or a copolymer of one or more amine-containing monomers or a copolymer of one or more amine-containing monomers in combination with one or more non-amine containing monomers, which are preferably inert and non-toxic. Examples of

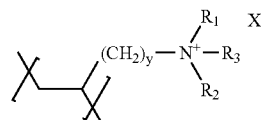
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suitable non-amine-containing monomers include vinyl alcohol, acrylic acid, acrylamide, and vinylformamide.

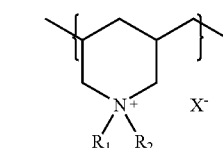
Examples of aliphatic amine polymers include polymers that have one or more repeat units selected from Formulas (1)-(6):



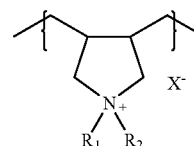
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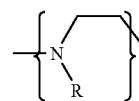
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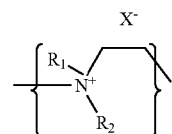
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(6)

or a salt or copolymer thereof, where y is zero or an integer of one or more (e.g., between about one and about 10, preferably between one and four, more preferably one) and each R , R_1 , R_2 , and R_3 , independently, is H , a substituted or unsubstituted alkyl group (e.g., having between 1 and 25 or between 1 and 5 carbon atoms, inclusive) or aryl (e.g., phenyl) group, and each X^- is an exchangeable negatively charged counterion.

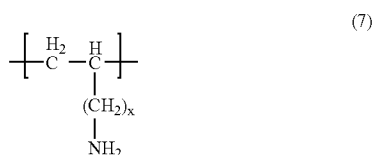
Preferably, at least one of R , R_1 , R_2 , or R_3 is a hydrogen atom. More preferably, each of these groups is hydrogen.

The alkyl or aryl group, represented by R , R_1 , R_2 , and R_3 , can carry one or more substituents. Suitable substituents include cationic groups, e.g., quaternary ammonium groups, or amine groups, e.g., primary, secondary or tertiary alkyl or aryl amines. Examples of other suitable substituents include hydroxy, alkoxy, carboxamide, sulfonamide, halogen, alkyl, aryl, hydrazine, guanidine, urea, poly(alkyleneimine) such as poly(ethyleneimine), and carboxylic acid esters.

Preferably, an aliphatic amine polymer is a homopolymer, such as a homopolyallylamine, homopolyvinylamine, homopolydiallylamine or polyethyleneamine.

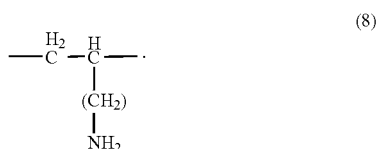
In one embodiment, the aliphatic amine polymer is a homopolymer or copolymer characterized by one or more repeat units of Structural Formula (7):

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or a pharmaceutically acceptable salt thereof, where x is 0 or an integer between 1 and 4, preferably 1. The polymer represented by Structural Formula (7) is advantageously crosslinked by means of a cross-linking agent.

A preferred aliphatic amine polymer for use in the invention is polyallylamine, which is a polymer having repeat units from polymerized allyl amine monomers. The amine group of an allyl monomer can be unsubstituted or substituted with, for example, one or two C1-C10 straight chain or branched alkyl groups. These alkyl groups are optionally substituted with one or more hydroxyl, amine, halo, phenyl, amide or nitrile groups. Preferably, the aliphatic amine polymers of present invention are polyallylamine polymers comprising repeat units represented by Structural Formula (8):



Polyallylamines that may be used as the aliphatic amine polymers of the present invention may include copolymers comprising repeat units from two or more different polymerized allyl monomers or with repeat units from one or more polymerized allyl monomers and repeat units from one or more polymerized non-allyl monomers. Examples of suitable non-allyl monomers include acrylamide monomers, acrylate monomers, maleic acid, malimide monomers, vinyl acrylate monomers and alkyl substituted olefines. Preferably, however, the polyallylamines used in the present invention comprise repeat units solely from polymerized allyl amine monomers. More preferably, the polyallylamine polymers used in the present invention are homopolymers. Even more preferably, the polyallylamine polymers used in the present invention are homopolymers of repeat units represented by Structural Formula (8). Polyallylamine polymers used in the disclosed invention are preferably crosslinked polymers, more preferably crosslinked homopolymers.

In other embodiments, the aliphatic amine polymer can be a homopolymer or copolymer of polybutenylamine, polylysine, or polyarginine.

Preferably, the aliphatic amine polymer is rendered water-insoluble by cross-linking such as with a cross-linking agent. Suitable cross-linking agents include those with functional groups which react with the amino group of the aliphatic amine monomer. Alternatively, the cross-linking agent may contain two or more vinyl groups which undergo free radical polymerization with the amine monomer. In some cases the aliphatic amine polymers are crosslinked after polymerization.

Aliphatic amine polymers are typically crosslinked with difunctional cross-linking agents. Examples of suitable cross-linking agents include diacrylates and dimethylacrylates (e.g., ethylene glycol diacrylate, propylene glycol diacrylate, butylene glycol diacrylate, ethylene glycol dimethacrylate, propylene glycol dimethacrylate, butylene glycol dimethacrylate, polyethyleneglycol dimethacrylate and polyethyleneglycol diacrylate), methylene bisacrylamide, methylene bismethacrylamide, ethylene bisacryla-

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mid, ethylene bismethacrylamide, ethylidene bisacrylamide, divinylbenzene, bisphenol A, the diglycidyl ether of bisphenol A, pyromellitic dianhydride, toluene diisocyanate, ethylene diamine and dimethyl succinate, dimethacrylate, and bisphenol A diacrylate. Examples of preferred difunctional crosslinking agents include epichlorohydrin, 1,4 butanedioldiglycidyl ether, 1,2 ethanedioldiglycidyl ether, 1,3-dichloropropane, 1,2-dichloroethane, 1,3-dibromopropane, 1,2-dibromoethane, succinyl dichloride, dimethylsuccinate, toluene diisocyanate, acryloyl chloride, and pyromellitic dianhydride. Epichlorohydrin is a most preferred crosslinking agent, because of its high availability and low cost. Epichlorohydrin is also advantageous because of its low molecular weight and hydrophilic nature, increasing the water-swellability and gel properties of the polyamine. Epichlorohydrin forms 2-hydroxypropyl crosslinking groups.

Other methods of inducing crosslinking on already polymerized materials include, but are not limited to, exposure to ionizing radiation, ultraviolet radiation, electron beams, radicals, and pyrolysis.

The level of cross-linking renders the aliphatic amine polymers insoluble and substantially resistant to absorption and degradation, thereby limiting the activity of the aliphatic amine polymer to the gastrointestinal tract, and reducing potential side-effects in the patient. Typically, the cross-linking agent is present in an amount from about 0.5-35% or about 0.5-25% (such as from about 2.5-20% or about 1-10%) by weight, based upon total weight of aliphatic amine monomer plus cross-linking agent. Typically, the amount of cross-linking agent is measured as a percentage of the combined weight of aliphatic amine polymer and crosslinking agent.

Typically, between about 9% and about 30% of the allylic nitrogen atoms are bonded to a crosslinking group, preferably between 15% and about 21%.

The aliphatic amine polymers can also be further derivatized; examples include alkylated amine polymers, as described, for example, in U.S. Pat. Nos. 5,679,717, 5,607,669 and 5,618,530, the teachings of which are incorporated herein by reference in their entireties. Preferred alkylating agents include hydrophobic groups (such as aliphatic hydrophobic groups) and/or quaternary ammonium- or amine-substituted alkyl groups.

Non-cross-linked and cross-linked polyallylamine and polyvinylamine are generally known in the art and are commercially available. Methods for the manufacture of polyallylamine and polyvinylamine, and cross-linked derivatives thereof, are described in the above U.S. Patents. Patents by Harada et al., (U.S. Pat. Nos. 4,605,701 and 4,528,347), which are incorporated herein by reference in their entireties, also describe methods of manufacturing polyallylamine and cross-linked polyallylamine. A patent by Stutts et al., (U.S. Pat. No. 6,180,754) describes an additional method of manufacturing cross-linked polyallylamine.

The molecular weight of aliphatic amine polymers is not believed to be critical, provided that the molecular weight is large enough so that the aliphatic amine polymer is non-absorbable by the gastrointestinal tract. Typically, the molecular weight of aliphatic amine polymers is at least 1000. For example the molecular weight can be from: about 1000 to about 5 million, about 1000 to about 3 million, about 1000 to about 2 million or about 1000 to about 1 million.

The aliphatic amine polymers used in the invention may be optionally protonated, and in one embodiment, include polymers in which less than 40%, for example, less than 30%, such as less than 20% or less than 10% of the amine groups are protonated. In another embodiment 35% to 45% of the

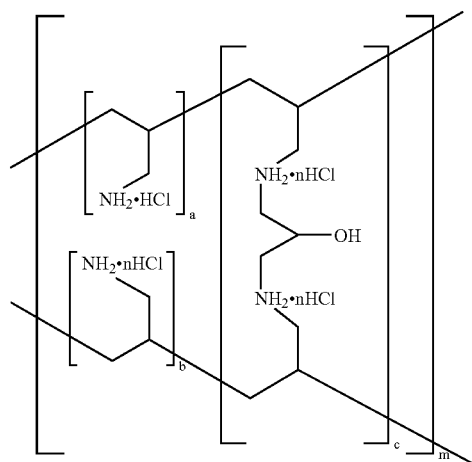
amines are protonated (e.g., approximately 40%). An example of a suitably protonated aliphatic amine polymer is sevelamer.

As described above, the aliphatic amine polymer can be administered in the form of a pharmaceutically acceptable salt. The term "pharmaceutically acceptable salt" refers to a salt of the aliphatic amine polymer to be administered prepared from pharmaceutically acceptable non-toxic acids including inorganic acids, organic acids, solvates, hydrates, or clathrates thereof. Thus, the nitrogen group in the repeat unit of the aliphatic amine polymer is protonated to create a positively charged nitrogen atom associated with a negatively charged counterion.

Examples of suitable counterions include organic ions, inorganic ions, or a combination thereof. For instance, suitable counterions include halides (e.g., F^- , Cl^- , Br^- and I^-), $CH_3OSO_3^-$, HSO_4^- , SO_4^{2-} , HCO_3^- , CO_3^{2-} , acetate, lactate, succinate, propionate, oxalate, butyrate, ascorbate, citrate, dihydrogen citrate, tartrate, taurocholate, glycocholate, cholate, hydrogen citrate, maleate, benzoate, folate, an amino acid derivative, a nucleotide, a lipid, or a phospholipid. Preferred anions are Cl^- , HCO_3^- , CO_3^{2-} , and a combination thereof (e.g., a mixed carbonate and bicarbonate salt, a mixed carbonate and chloride salt, or a mixed bicarbonate and chloride salt). The counterions can be the same as, or different from, each other. For example, the polymer can contain two or more different types of counterions.

In a preferred embodiment, the aliphatic amine polymer used in the present invention is an epichlorohydrin cross-linked polyallylamine, such as sevelamer and colesevelam (see, for example, U.S. Pat. Nos. 6,423,754; 5,607,669; and 5,679,717, the contents of which are incorporated herein by reference). In a preferred embodiment, the polyallylamine polymer is crosslinked with epichlorohydrin and between about 9% to about 30% (preferably about 15% to about 21%) of the allylic nitrogen atoms are bonded to a crosslinking group and the anion is chloride, carbonate or bicarbonate or a mixed salt thereof.

A particularly preferred aliphatic amine polymer is polyallylamine hydrochloride crosslinked with about 9.0-9.8% w/w epichlorohydrin, preferably 9.3-9.5%, and is the active chemical component of the drug known as sevelamer HCl, sold under the tradename RENAGEL®. The structure is represented below:



where:

the sum of a and b (the number of primary amine groups) is 9;

c (the number of crosslinking groups) is 1;

n (the fraction of protonated amines) is 0.4; and

m is a large number (to indicate extended polymer network).

Another particularly preferred aliphatic amine polymer is polyallylamine hydrochloride crosslinked with epichlorohydrin and alkylated with 1-bromodecane and (6-bromohexyl)-trimethylammonium bromide, referred to as colesevelam HCl, and marketed in the United States as WELCHOL®.

In yet another particularly preferred embodiment, the aliphatic amine polymer is a carbonate salt of sevelamer; a bicarbonate salt of sevelamer; a mixed carbonate and bicarbonate salt of sevelamer; or a mixed carbonate and chloride salt of sevelamer.

In other embodiments, a monovalent anionic source is mixed with a carbonate salt of the aliphatic amine polymer. Various examples of carbonate salts of the aliphatic amine polymer and monovalent anionic sources are disclosed in U.S. Provisional Application No. 60/624,001 "Aliphatic Amine Polymer Salts For Tableting" filed Nov. 1, 2004 and U.S. Provisional Application No. 60/628,752 "Aliphatic Amine Polymer Salts For Tableting" filed Nov. 17, 2004, the entire contents of which are incorporated herein by reference.

The monovalent anion comprises at least 0.01%, preferably 0.05%, more preferably a range of 0.01% to 2%, 0.05% to 1%, 0.08% to 0.5%, or 0.1% to 0.3% by weight of the combined weights of the carbonate salt of aliphatic amine polymer and the monovalent anion source.

Examples of suitable monovalent anions include organic ions, inorganic ions, or a combination thereof, such as halides (Cl^- , I^- , Br^- and NO_3^-), $CH_3OSO_3^-$, HSO_4^- , acetate, lactate, butyrate, propionate, sulphate, citrate, tartrate, nitrate, sulfonate, oxalate, succinate or palmoate. Preferred monovalent anions are halides, most preferably chloride.

Also, the monovalent anion source can be a pharmaceutically acceptable acid, ammonium or metal salt of a monovalent anion. Preferably the monovalent anion source is sodium chloride or hydrochloric acid. In one preferred embodiment, the formulations of the invention comprise a carbonate salt of sevelamer and sodium chloride. In another preferred embodiment, the formulations of the invention comprise a carbonate salt of sevelamer and hydrochloric acid.

In yet another preferred embodiment, the monovalent anion source can be a monovalent anion salt of an aliphatic amine polymer comprising a repeat unit represented by Structural Formulas (1)-(8) above. The formulations of the invention can comprise a "physically mixed polymer" or a "chemically mixed polymer". The combination of a carbonate salt of an aliphatic amine polymer and a monovalent anion salt of an aliphatic amine polymer is defined herein as a "physically mixed polymer". The monovalent anion salt of the aliphatic amine polymer can be the same or a different aliphatic amine polymer as the aliphatic amine polymer carbonate salt. Herein, a "chemically mixed polymer" means the combination of a carbonate salt and a monovalent anion salt on a single aliphatic amine polymer.

In some embodiments, the aliphatic amine polymer or pharmaceutically acceptable salt thereof is the only pharmaceutically active ingredient in the powder formulations.

The powder formulations of the invention for use in a subject comprise the aliphatic amine polymer and the pharmaceutically acceptable anionic stabilizer(s), optionally together with one or more acceptable excipients therefor. The excipients include carriers or diluents, such as lactose, starch, cellulose and dextrose; flavoring agents; sweeteners; and pre-

servatives, such as methyl, ethyl, propyl and butyl parabens. Optionally, for a good appearance, excipients, such as micro-crystalline cellulose, titanium dioxide, and/or coloring agents, such as FD&C Blue #1, FD&C Red #40, D&C Yellow #10, D&C Red #33, or yellow iron oxide, can also be included in the powder formulations of the invention. Examples of suitable sweeteners include sucrose; glucose (corn syrup); dextrose; invert sugar; fructose; saccharin and its various salts, such as sodium saccharinate; sodium, aspartame, xylose; maltitol; maltol; potassium acesulfame; neohesperidin dihydrochalcone; monoammonium glycyrrhizinate; maltodextrin and polydextrose saccharin and its various salts such as the sodium and calcium salts; cyclamic acid and its various salts; dipeptide sweeteners; sucralose; dihydrochalcone; glycyrrhin; Stevia rebaudiana (Stevioside); sorbitol; mannitol; xylitol; hexa-resorcinol; hydrogenated starch hydrolysate (lycasin), and the potassium, calcium and sodium salts of 3,6-dihydro-6-methyl-1-1,2,3-oxathiazin-4-on 3-2,2-dioxide, and a mixture of thereof. Of the foregoing, sucralose, sucrose, xylose, mannitol, maltitol, maltol, sorbitol or xylitol is particularly preferred, either alone or more desirably in combination. Suitable flavorings include grape, cherry, peppermint, menthol and vanilla flavors, such as orange vanilla flavor, lemon flavor, spearmint, wintergreen, cinnamon, menthone flavors, or a mixture thereof. The excipients must be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

Typically, the average particle size of the powder of the invention is less than 500 microns, preferably less than 200 microns. In some embodiments, the powder contains less than 5 wt %, preferably less than 2 wt %, more preferably less than 1 wt %, of particles having a particle size more than 300 microns and less than 5 wt %, preferably less than 2 wt %, more preferably less than 1 wt %, of particles having a particle size less than 10 microns.

The disclosed powder formulation is typically dissolved and/or suspended in an ingestible liquid such as water. The resulting mixture has a pleasant mouth-feel and therefore can be conveniently administered to a patient as a drink. The drink can be a suspension or solution. The drink can be even more palatable with one or more sweeteners and/or flavorants. Alternatively, the disclosed powder formulation can be mixed with foods, such as mashed potatoes or oatmeal.

The powder formulations of the invention can be conveniently packaged in a container. Herein, a "container" is a non-ingestible containment device which can hold and preserve the stability of the powder formulation of the invention for a sufficient period of time, i.e., from the time of manufacture to the time of consumption by patients. As noted above, the powder formulation is uncapsulated and free-flowing. Containers suitable for the present invention include a sachet, such as a paper bag, powder bag of plastic films or metal foils; a bottle, such as a glass, plastic or metal bottle; a tub; and an ampule. Preferably, the container of the invention is a sachet. The container material is preferably impermeable to water and water vapor in order that the stability of the active agent contained in the container is ensured. Optionally, the container materials can contain substances which impart a particular type of protection, for example protection against light, to the contents. Examples of suitable container materials include plastics, such as MATT LACQUER/PET 23μ/PX 12 GR/AL 12μ/SURLYN 23 GR (AMCOR Flexibles in Victoria, Australia), coated papers, such as Coated Paper 40GR/PX 12 GR/AL 12μ/SURLYN 23 GR (AMCOR Flexibles in Victoria, Australia), foil pouches, such as TPC-2475 (TOLAS

Health Care Packaging in Feasterville, Pa.), and a combination of these materials (e.g., laminates).

Preferably, the container is a multi-layer container having multiple layers of different container materials discussed above.

The container containing the powder formulation of the invention can be a unit-dose or a multi-dose container. For example, the container of the invention can contain a single dose of the aliphatic amine polymer mixed with the pharmaceutically acceptable anionic stabilizer, such as a single-dose sachet. Alternatively, the container of the invention can contain at least two doses of the aliphatic amine polymer mixed with the pharmaceutically acceptable anionic stabilizer, such as a bottle or tub with the powder formulation from which a unit dose is measured by, e.g., a spoon or cup, or an instrument capable of dispensing a pre-defined dosage amount. Herein, a "tub" means a container containing a bulk quantity of the powder formulation. A "bulk quantity" means an amount out of which a plurality of unit doses can be divided, e.g., 2, 10, 50, 100 or more unit doses.

The powder formulations of the invention can be prepared by any of the methods known in the art of pharmacy. For example, standard pharmaceutical formulation techniques such as those described in Remington's Pharmaceutical Sciences, 18th ed. (1990), Mack Publishing Company, Easton, Pa., the disclosure of which is incorporated herein by reference, can be used. Typically, the methods include the steps of mixing at least one aliphatic amine polymer with one or more pharmaceutically acceptable anionic stabilizers, and bringing into association the resulting mixture with any additional excipients. In general, the formulations are prepared by uniformly and intimately bringing the aliphatic amine polymer into association with the pharmaceutically acceptable anionic stabilizers and then, if necessary, dividing the product into unit dosages thereof. The powder formulation is then packaged within a suitable container, such as a sachet.

Typically, the container holds a unit dose which is generally about 5 mg to about 15 g (e.g., 600 mg-7.5 g, 600 mg-5 g, 800 mg-3.5 g and 800 mg-2.5 g) of the aliphatic amine polymer on an anhydrous basis if administered once a day. Typically, about 0.025 mg to about 14.9 g (e.g., 3 mg-7.5 g; 3 mg-5 g; 8 mg-3.5 g; 8 mg-2.5 g; 6 mg-2.5 g, 6 mg-1.5 g, 6 mg-0.75 g) of a pharmaceutically acceptable anionic stabilizer is included in the unit dose together with the aliphatic amine polymer. Alternatively, the container holds a unit dose which is generally the daily dosage divided by the number of administration per day if administered multiple times per day (e.g., 2, 3, 4, or 5 times/day). In one example, a sachet contains either 800 mg, 1.6 g, 2.4 g, 3.2 g, 4.0 g, 4.8 g, 5.6 g, 7.2 g or 9.6 g of sevelamer on an anhydrous basis, and further contains propylene glycol alginate and optional excipients, such as sucrose, xylose, mannitol, maltitol, maltol, sodium chloride, yellow iron oxide, orange vanilla flavor and lemon flavor mixed with sevelamer.

The powder formulation may be introduced by a patient into a suitable amount of liquid, preferably water, to form a therapeutic formulation in situ, and the therapeutic formulation is then taken by the patient. The therapeutic formulation can be an aqueous-based therapeutic formulation or a non-aqueous formulation, preferably aqueous-based formulation, in which the aliphatic amine polymer and anionic stabilizer are each independently dissolved or suspended. Aqueous-based therapeutic formulations can be formed by adding the powder formulation within a container into a suitable aqueous vehicle, such as water, before administration. Non-aqueous therapeutic formulations can be obtained by dispersing in a suitable non-aqueous based vehicle, such as almond oil, ara-

chis oil, soyabean oil, fractionated coconut oil, olive oil, poppy-seed oil or maize oil before administration. Alternatively, the powder formulations of the invention may be administered by a patient via direct ingestion. That is, a unit dose of the powder is administered directly into a mouth of the patient and then swallowed, preferably with the aid of water or any other ingestible liquid. Optionally, the powder formulations of the invention may be administered by a patient as a mixture with foods.

The powder formulations of the invention can be used for treating hyperphosphatemia in a subject. Hyperphosphatemia is typically defined for humans as a serum phosphate level of greater than about 4.5 mg/dL. The condition, especially if present over extended periods of time, leads to severe abnormalities in calcium and phosphorus metabolism and can be manifested by aberrant calcification in joints, lungs and eyes. Elevated serum phosphate is commonly present in patients with renal insufficiency, hypoparathyroidism, pseudohypoparathyroidism, acute untreated acromegaly, overmedication with phosphate salts, and acute tissue destruction as occurs during rhabdomyolysis and treatment of malignancies.

As used herein a subject is a mammal, preferably a human, but can also be an animal in need of veterinary treatment, such as a companion animal (e.g., dogs, cats, and the like), a farm animal (e.g., cows, sheep, pigs, horses, and the like) or a laboratory animal (e.g., rats, mice, guinea pigs, and the like). A subject "in need of treatment" includes a subject with chronic renal failure. Other examples of subjects in need of treatment include patients with a disease associated with disorders of phosphate metabolism. Examples of diseases and/or disorders of this type include hyperparathyroidism, inadequate renal function, and hyperphosphatemia.

An "effective amount" of an aliphatic amine polymer is a quantity that results in a beneficial clinical outcome of or exerts an influence on, the condition being treated with the aliphatic amine polymer compared with the absence of treatment. The amount of an aliphatic amine polymer administered to the subject will depend on the degree, severity, and type of the disease or condition, the amount of therapy desired, and the release characteristics of the pharmaceutical formulation. It will also depend on the subject's health, size, weight, age, sex and tolerance to drugs. Typically, the composition of the invention is administered for a sufficient period of time to achieve the desired therapeutic effect. Typically between about 5 mg per day and about 15 g per day of an aliphatic amine polymer (alternatively between about 50 mg per day and about 10 g per day, alternatively between about 1 g per day and about 10 g per day, alternatively between about 1 g per day and about 8 g per day, alternatively between about 2 g per day and about 8 g per day, alternatively between about 4 g per day and about 8 g per day) is administered to the subject in need of treatment. These dosages can be administered several times/day (e.g., 2, 3, 4 or 5 times/day) or once/day. The aliphatic amine polymer can be administered at least four times per day with meals, at least three times per day with meals, at least twice per day with meals, at least once per day with meals, (see U.S. Provisional Application No. 60/623, 985, "Once a day formulation for phosphate binders" filed Nov. 1, 2004, the entire contents of which are incorporated herein by reference). In one specific example, about 0.8-7.2 g (e.g., 2.4 g or 3.2 g per dose for 2-3 times per day, or 4.0 or 4.8 g per dose for 2-3 times per day, or 7.2 g per dose for once per day) of the aliphatic amine polymer is administered per day.

Typically, the formulations of the invention can be administered before or after a meal, or with a meal. As used herein, "before" or "after" a meal is typically within two hours, preferably within one hour, more preferably within thirty

minutes, most preferably within ten minutes of commencing or finishing a meal, respectively.

The method of the present invention includes a monotherapy where the powder formulations of the invention are used alone. The method of the present invention also includes a co-therapy with other therapeutically active drugs. For example, the method of the present invention can be used with other phosphate binders including pharmaceutically acceptable lanthanum, calcium, aluminum and iron salts, such as acetates, carbonates, oxides, hydroxides, citrates, alginates, and ketoacids. Calcium salts, including calcium carbonate, acetate (such as PhosLo® calcium acetate tablets), citrate, alginate, and ketoacids, have been utilized for phosphate binding. The ingested calcium combines with phosphate to form insoluble calcium phosphate salts such as $\text{Ca}_3(\text{PO}_4)_2$, CaHPO_4 , or $\text{Ca}(\text{H}_2\text{PO}_4)_2$. Aluminium-based phosphate binders, such as Amphojel® aluminium hydroxide gel, have also been used for treating hyperphosphatemia. These compounds complex with intestinal phosphate to form highly insoluble aluminium phosphate; the bound phosphate is unavailable for absorption by the patient. More recently iron and lanthanide salts have been used. The most commonly used lanthanide salt, lanthanum carbonate (Fosrenol®) behaves similarly to calcium carbonate.

Those skilled in the art will be aware that the amounts of the various components of the formulations of the invention to be administered in accordance with the method of the invention to a subject will depend upon those factors noted above.

The invention is illustrated by the following examples which are not intended to be limiting in any way.

EXEMPLIFICATION

Example 1

Compositions of Powder Formulations of the Invention

The powder formulations were prepared by standard pharmaceutical formulation techniques such as those described in Remington's Pharmaceutical Sciences, 18th ed. (1990), Mack Publishing Company, Easton, Pa. Specific compositions of two exemplary powder formulations (Formulas A and B) of the invention are summarized in Table 1 below:

TABLE 1

Compositions of the Powder Formulations		
Ingredient	Formula A (wt %)	Formula B (wt %)
Anhydrous Sevelamer HCl	—	92.90
Anhydrous Sevelamer carbonate	94.97	
PGA	1.00	3.00
Orange Vanilla PR90	2.00	2.00
WG55 Vanilla	0.50	0.50
Lemon Lime	0.11	0.12
NaCl	1.00	1.00
Sucralose	0.40	0.45
Yellow iron oxide	0.016	0.016

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

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What is claimed is:

1. A powder in a container, the powder comprising a mixture of:

- a) a pharmaceutically acceptable anionic stabilizer comprising propylene glycol alginate;
- b) carbonate salt of sevelamer mixed with the anionic stabilizer, wherein the amount of the sevelamer carbonate is 800 mg on an anhydrous basis; and
- c) sodium chloride;

wherein:

- i) the container is a sachet and the ratio of the anionic stabilizer to sevelamer carbonate is 0.005-1:1; and
- ii) the only pharmaceutically active ingredient in the powder is the sevelamer carbonate.

2. The powder of claim 1, wherein the powder is uncapsulated and free-flowing, and wherein the powder contains less than 5 wt % of particles having a particle size more than 300 microns and less than 5 wt % of particles having a particle size less than 10 microns.

3. The powder of claim 1, wherein the powder further comprises a pharmaceutically acceptable flavoring agent.

4. The powder of claim 1, wherein the powder further comprises a pharmaceutically acceptable sweetener.

5. The powder of claim 4, wherein the pharmaceutically acceptable sweetener includes at least one member selected from the group consisting of sucralose, sucrose, xylose, mannitol, maltitol, maltol, sorbitol and xylitol.

6. The powder of claim 1, wherein the pharmaceutically acceptable flavoring agent includes at least one member selected from the group consisting of grape, cherry, peppermint, menthol, vanilla flavor, orange vanilla flavor, lemon flavor, spearmint, wintergreen, cinnamon, and menthone flavors.

7. The powder of claim 4, wherein the pharmaceutically acceptable sweetener is sucralose.

8. The powder of claim 1, wherein the powder further comprises a pharmaceutically acceptable coloring agent.

9. The powder of claim 8, wherein the pharmaceutically acceptable coloring agent is yellow iron oxide.

10. A powder in a container, the powder comprising a mixture of:

- a) a pharmaceutically acceptable anionic stabilizer comprising propylene glycol alginate;
- b) carbonate salt of sevelamer mixed with the anionic stabilizer, wherein the amount of the sevelamer carbonate is 2.4 g on an anhydrous basis; and
- c) sodium chloride;

wherein:

- i) the container is a sachet and the ratio of the anionic stabilizer to sevelamer carbonate is 0.005-1:1; and
- ii) the only pharmaceutically active ingredient in the powder is the sevelamer carbonate.

11. The powder of claim 10, wherein the powder is uncapsulated and free-flowing, and wherein the powder contains less than 5 wt % of particles having a particle size more than 300 microns and less than 5 wt % of particles having a particle size less than 10 microns.

12. The powder of claim 10, wherein the powder further comprises a pharmaceutically acceptable flavoring agent.

13. The powder of claim 12, wherein the pharmaceutically acceptable flavoring agent includes at least one member selected from the group consisting of grape, cherry, peppermint, menthol, vanilla flavor, orange vanilla flavor, lemon flavor, spearmint, wintergreen, cinnamon, and menthone flavors.

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14. The powder of claim 10, wherein the powder further comprises a pharmaceutically acceptable sweetener, comprising at least one member selected from the group consisting of sucralose, sucrose, xylose, mannitol, maltitol, maltol, sorbitol and xylitol.

15. The powder of claim 14, wherein the pharmaceutically acceptable sweetener is sucralose.

16. The powder of claim 10, wherein the powder further comprises a pharmaceutically acceptable coloring agent.

17. The powder of claim 16, wherein the pharmaceutically acceptable coloring agent is yellow iron oxide.

18. A powder in a container, the powder comprising a mixture consisting essentially of:

- a) a pharmaceutically acceptable anionic stabilizer comprising propylene glycol alginate and glycerol alginate;
- b) carbonate salt of sevelamer mixed with the anionic stabilizer;
- c) sodium chloride; and
- d) optionally one or more of a pharmaceutically acceptable flavoring agent, sweetener, or coloring agent;

wherein:

- i) the container is a sachet and the ratio of the anionic stabilizer to sevelamer carbonate is 0.005-1:1; and
- ii) the only pharmaceutically active ingredient in the powder is the sevelamer carbonate.

19. The powder of claim 18, wherein the powder is uncapsulated and free-flowing, and wherein the powder contains less than 5 wt % of particles having a particle size more than 300 microns and less than 5 wt % of particles having a particle size less than 10 microns.

20. The powder of claim 18, wherein the powder comprises a pharmaceutically acceptable flavoring agent.

21. The powder of claim 20, wherein the pharmaceutically acceptable flavoring agent includes at least one member selected from the group consisting of grape, cherry, peppermint, menthol, vanilla flavor, orange vanilla flavor, lemon flavor, spearmint, wintergreen, cinnamon, and menthone flavors.

22. The powder of claim 18, wherein the powder comprises a pharmaceutically acceptable sweetener, comprising at least one member selected from the group consisting of sucralose, sucrose, xylose, mannitol, maltitol, maltol, sorbitol and xylitol.

23. The powder of claim 22, wherein the pharmaceutically acceptable sweetener is sucralose.

24. The powder of claim 18, wherein the powder comprises a pharmaceutically acceptable coloring agent.

25. The powder of claim 24, wherein the pharmaceutically acceptable coloring agent is yellow iron oxide.

26. The powder of claim 1, wherein the chloride of the sodium chloride is present in a range of between 0.01-2 wt. % relative to the combined weights of the sevelamer carbonate and the sodium chloride.

27. The powder of claim 10, wherein the chloride of the sodium chloride is present in a range of between 0.01-2 wt. % relative to the combined weights of the sevelamer carbonate and the sodium chloride.

28. The powder of claim 18, wherein the chloride of the sodium chloride is present in a range of between 0.01-2 wt. % relative to the combined weights of the sevelamer carbonate and the sodium chloride.